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Multi-Dimensional Data Assimilation for Physical-Biological Models

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LONG-TERM GOALS

The long-term goal of our research is to develop mathematical models that can be used to obtain better understanding of the interactions between physical and biological processes in marine ecosystems and their role in structuring marine food webs.

OBJECTIVES

To accomplish our long-term goal we are pursuing the following research objectives: 1) develop approaches for assimilating multidisciplinary measurements into marine ecosystem models; 2) use data assimilation techniques with physical-biological models to investigate the types of data and frequency at which data need to be assimilated; and 3) use the data assimilation techniques to investigate the structure of marine ecosystem models. These research objectives are directed at developing techniques and approaches that are needed for the full capability of multidisciplinary measurement programs to be realized.

APPROACH

The amount and type of data needed for input to data-assimilative multi-component marine ecosystem models are currently determined empirically for each model. This approach lacks rigor and generality and results in data-assimilative approaches that are model specific. Empirical Orthogonal Function (EOF) techniques were used in an attempt to determine data needs for marine ecosystem models. Using EOF analysis, data can be decomposed into orthogonal functions and their corresponding temporal coefficients. These EOF structures allow determination of the primary interconnections of the ecosystem, which, in turn, allows insight into the processes that need to be well represented in the corresponding forward model. The EOF model uses the eigenstructures from a given data set and modifies a forward model with the aim of nudging the model towards the prescribed data set. The overall approach may useful for combining data and forward models in a data assimilative mode.

WORK COMPLETED

The ecosystem models, that are representative of each of the data sets we are using, have been developed as has the corresponding EOF model. Simulations have been completed and we are analyzing the results. A presentation on the models and EOF results will be given at the Ocean

Sciences Meeting, scheduled for January 2000. Manuscripts describing the numerical twin experiments and those using field and laboratory observations are in preparation.

RESULTS

A five component, three-depth marine ecosystem model was developed to mimic the spring bloom in the upper Chesapeake Bay. In numerical twin experiments, the EOF model was able to accurately reproduce this forward model using only a limited number of eigenstructures. However, when the Chesapeake Bay data was used to create the eigenstructures, the EOF model was able to approximate the forward model only when the full complement of eigenstructures was used. Analyses show that the EOF model is sensitive to perturbations of the eigenstructures, which suggests that the dynamics of the forward model are not appropriate for the data set, different formulations are needed in the model, or that a reworking of the eigenstructures is needed. Additional studies using data sets from more controlled environments, such as laboratory studies, provide insight into resolving the uncertainty arising from data-model mismatches.

IMPACT/APPLICATIONS

Our results show that the combined EOF-data assimilation model is a promising approach for combining data and models at certain space and time scales. The approach also provides a diagnostic procedure for determining the level of mismatch between dynamics included in the forward model and those included in the data sets input to the model.

RELATED PROJECTS

1. This project is joint with Dr. Percy Donaghay at the University of Rhode Island.

2. The results of this research are being used as part of a NSF/NASA funded Joint Global Ocean Flux Study, Synthesis and Modeling Project that is focused on development of data assimilative biological models.

REFERENCES

Haskell, A.G.E., J.M. Klinck and E.E. Hofmann, EOF Technique Applied to a Multi-Component Ecosystem Model, *EOS*, 79(45), F432.